

Benefits of a Flexible Electrical Test Platform

TERADYNE

Assembly Test Division

Presentation Overview

- PCB assembly electrical test challenges
 - Simple versus complex technologies
 - Low cost versus high value
 - High volume versus high mix
 - Regulatory obligations
 - Multi-site manufacturing issues
 - Operator skill levels
- Electrical test alternatives
 - MDA versus ICT capabilities
 - Multi-tester versus single tester strategies
- Teradyne's scalable test platform
 - TestStation's unique design and capabilities
 - New pin boards for TestStation platform
 - New operator integrated debug environment
 - Benefits

Manufacturers Face Diverse Electrical Test Challenges

- Different PCB complexities
 - Simple versus complex technologies
 - Low net count versus high net count PCBs
 - Full test access versus limited test access
- Different product costs
 - Low cost consumer products
 - High cost server, networking, and military products
- Different reliability & regulatory test obligations
 - Safety concerns for automotive, mil/aerospace, and medical products
 - “Throw-away” consumer products

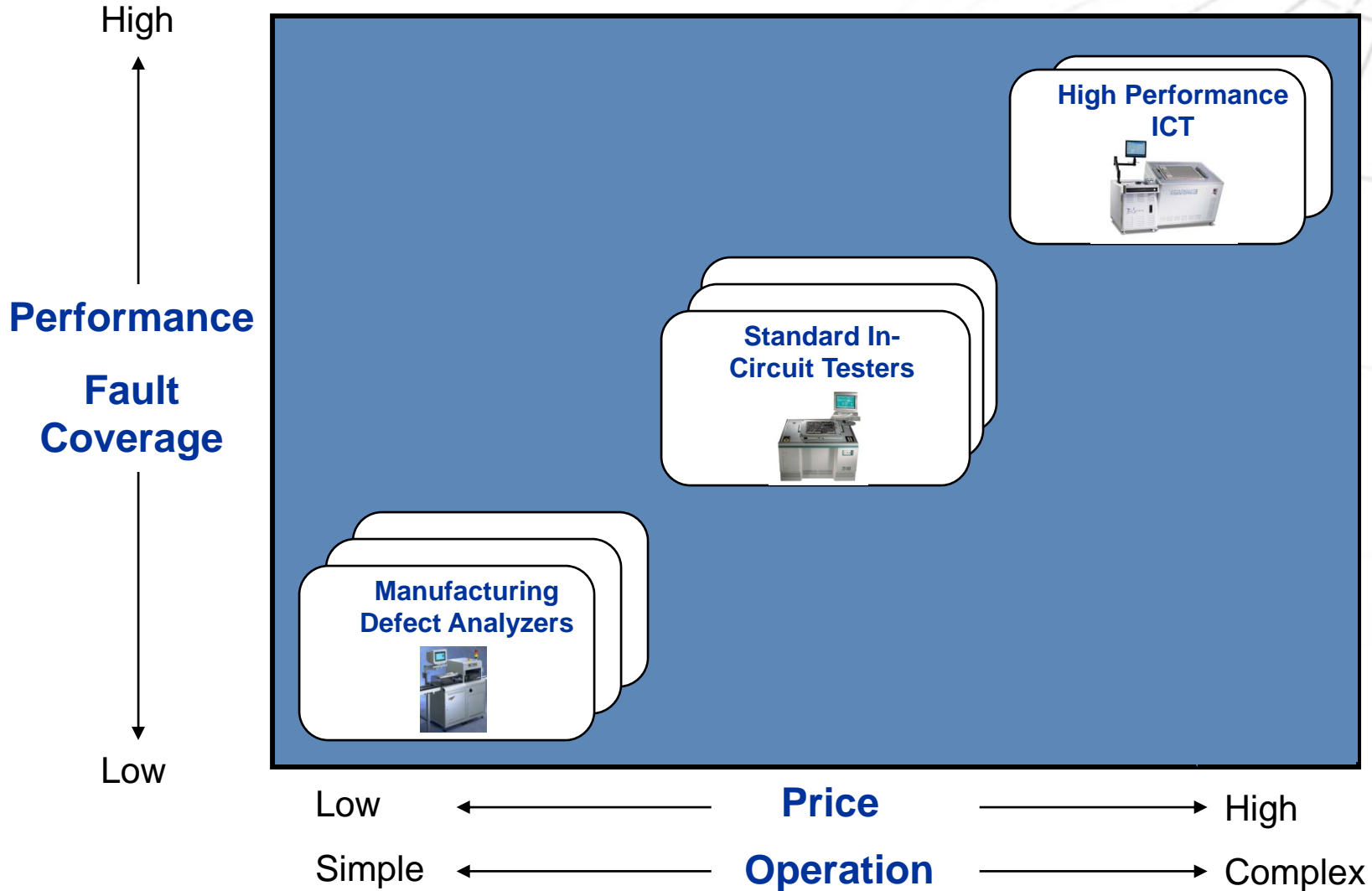


Manufacturers Face Diverse Electrical Test Challenges

- Different manufacturing strategies
 - Outsourced mfg versus internal mfg
 - Multi-national EMS corporations
 - Multi-site manufacturing
 - Frequent changes to location where product is manufactured
- Different product volumes and mix
 - High mix New Product Introduction (NPI) facilities
 - Dedicated high volume manufacturing lines
 - Automated versus operator driven manufacturing lines
- Different operator skill levels
 - Experienced technicians versus inexperienced operators
 - Trained versus un-trained personnel



Bed-Of-Nails Electrical Test Alternatives



Bed-Of-Nails Electrical Testers – Capability Comparison

Test Techniques

Tester Type	Shorts and Opens	Un-Powered Analog (R,L,C)	Vector-less Tests	Powered Analog	Powered Functional	Boundary Scan	Basic Digital	Advanced Digital
MDA	✓	✓	✗	✗	✗	✗	✗	✗
MDA+	✓	✓	✓	✓	✗	✓	✗	✗
ICT	✓	✓	✓	✓	✓	✓	✓	✗
ICT+	✓	✓	✓+	✓	✓+	✓+	✓+	✓

Each class of testers have different fault detection capacity

Today's Manufacturing Dilemma...

One Size Does NOT Fit All

- MDA class testers cannot adequately test complex PCB assemblies
 - Limited power-up capabilities
 - Limited vector-less test capabilities
 - No digital vector test capabilities
 - Uncertain fault coverage
- Implementing a multi-system test strategy has hidden costs
 - Training and service costs
 - Program maintenance costs
 - Reduced flexibility in test equipment utilization
- High performance ICT can be too expensive and complex for testing simple PCB assemblies
 - Constant pressure to reduce costs and improve margins
 - Program development requires higher-skilled operators
 - High performance ICT features are not always needed



TestStation Solution – Flexible Test Platform



- Designed to be scalable from MDA+ to ICT+
 - Analog only to high performance digital test capabilities
 - Low to very high pin count configurations
 - Pure pin or multiplexed operation
 - Simple to powerful operator interfaces
 - Tester can be upgraded (or downgraded) on-site without swapping the system
- Designed with advanced test technologies
 - UltraPin II for safe, accurate, and reliable testing of ultra-low voltage technologies
 - Framescan FX vectorless test for ultra-fine component packages and connectors
 - Support for native or third-party boundary scan and PLD programming solutions
- Designed to be Automation Ready
 - ICT system available as components for easy integration into automated handlers
- Designed to be affordable
 - Recently re-designed for optimum price/performance value
 - Lower starting prices and higher performance

TestStation: Scalable Product Family



TestStation LH



TestStation



TestStation LX

Pure Pin

Multiplexed

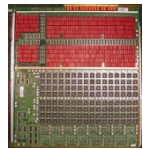
Test Options

Pin Capacity

Common Instruments and Options

Common Software Environment

Common SafeTest Technologies



DANGER

LOW VOLTAGE



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TestStation Rackmount System (TSR)

Customized High-Volume Automation Solutions...

- **TSR Rackmount Components**

- Pin board / instrument cage
- System supplies
- Power controller assembly
- DUT supplies
- Computer



- **Customizable Configurations**

- Three different receiver options
- Vacuum or press down Implementations
- Selectable multiplexing options
- 2,048 pin ZIF receiver

- **Automation Handler Partners**

- Nutek, IPTE, etc.



Scalable Hardware Features

- Clock/Sync/Trigger VLSI test capabilities
 - For advanced digital device testing and timing control
- Backdrive measurement and high accuracy features
 - For increased accuracy and safety when testing low-voltage technologies
- System frequency test module
 - Frequency and time event measurements
- Power supplies
 - Up to 14 programmable and three fixed user supplies
- Deep serial memory module
 - For enhanced performance of FLASH/ISP/BSCAN applications
- Analog functional test module
 - For complex analog and mixed signal device testing
- Custom function board
 - Vehicle control interface for automotive protocols
 - Integration of custom and third-party test application circuitry



TestStation - Designed to Safely Test Low Voltage Technologies

- UltraPin driver/sensors
 - Closed loop, low impedance pin
 - 40mV/15mV D/S accuracy
 - Real-time current measurement
 - Automatic driver verification
 - Programmable per-pin logic levels
 - Dual-level thresholds

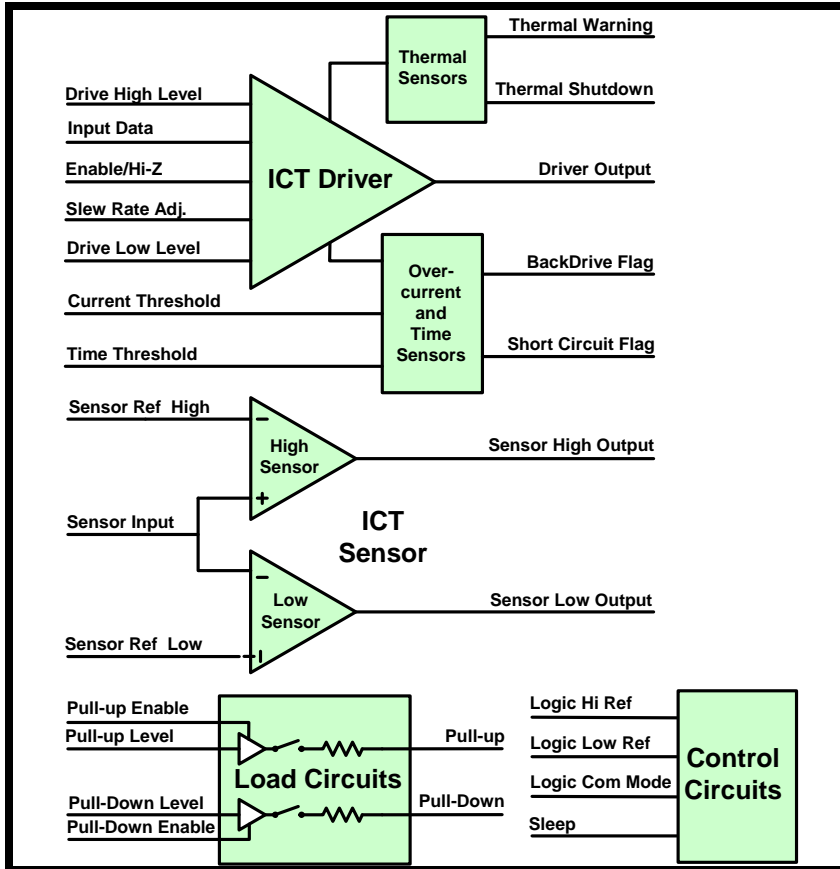
- Dedicated digital controller
 - Fast test throughput
 - Consistent and repeatable timing
 - Reduced backdrive duration
 - Clock drive and trigger pins

- Powerful test software
 - Multi-level digital isolation
 - Accurate pin-level diagnostics
 - Programmable backdrive controls
 - Backdrive measurement reports




	High Accuracy D/S	Programmable Per Pin Logic Levels	Dedicated Digital Controller	Automatic Driver Verification	Backdrive Measurement	Programmable Backdrive Control	Multi-Level Digital Isolation
TestStation	✓	✓	✓	✓	✓	✓	✓
GR228X	X	✓	✓	✓	X	X	✓
System A	X	✓	✓	X	X	X	X
System B	✓	X	X	✓	X	X	X

TestStation - Award Winning UltraPin Technology



Custom ASIC IC designed specifically to achieve Teradyne's specification and functionality


 US006114848A

United States Patent [19] Patent Number: **6,114,848**
 Suto et al. [45] Date of Patent: **Sep. 5, 2000**

[54] **DIRECT-MEASUREMENT PROVISION OF SAFE BACKDRIVE LEVELS** FOREIGN PATENT DOCUMENTS
 0415319A2 6/1991 European Pat. Off. G06F 11/22

[75] Inventors: **Anthony J. Suto, Sterling; Robert J. Muller, Westford; John D. Moniz, Fall River, all of Mass.** *Primary Examiner—Safet Metjabic
 Assistant Examiner—Jimmy Nguyen
 Attorney, Agent, or Firm—Cesari and McKenna, LLP*

[73] Assignee: **GenRad, Inc., Westford, Mass.** [57] **ABSTRACT**

[21] Appl. No.: **09/231,001** Pin-driver circuitry in each of an automatic circuit tester (10)'s digital driver/sensor circuits (36) includes a current

[22] Filed: **Jan. 14, 1999**

- Low output impedance, closed loop driver
- Integrated, real-time backdrive detection
- Dual threshold sensor
- Programmable load circuits
- Driver output monitoring

Industry Recognition:

- 2000 US patent for real-time backdrive current measurement capabilities
- 2004 IPC Innovative Technology Showcase
- 2004 *Test and Measurement World* “Best in Test” Nominee”

UltraPin II: Next-Generation ICT Pin

- New pin technology for TestStation
 - New Driver/Sensor pin electronics
 - The most accurate ICT pin
 - Improved drive and sense accuracy
 - Improved backdrive detection capability
 - Designed for safe, accurate, and reliable testing of ultra-low voltage technologies
 - Six times more accurate than nearest competitive ICT pin
 - Designed with future technologies in mind
 - Lower cost and higher performance than UltraPin I
 - Un-compromised performance, ***no feature reduction***
 - Compatible with UltraPin I specification

TEST STATION
With UltraPin II



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Pin Electronics Comparison

Parameter	TestStation UltraPin	TestStation UltraPin II
Digital Pin Architecture		
	Pure Pin and Muxed	Pure Pin and Muxed
Driver		
Voltage Compliance	-2.5V to +5.5V	-2.5V to +5.5V
Slew Rate	50 to 300V/usec	100 to 300V/usec
Max Vector Rate	5Mhz	5Mhz
Output Current	+/- 600mA minimum	+/-600mA minimum
Max. Initial Offset Error	+/-45mV	< +/-15mV
Typical Initial Offset Error	+/-16mV	+/-3mV
Path Impedance	< 0.6 Ohm Typ.	< 0.6 Ohm
Max Backdrive IR error @ 500mA	300mV	300mV
Programming Resolution	8mV	2.3mV
Backdrive Detection Range	+/- 50mA to 600mA	+/- 15mA to 500mA
Sensor		
Voltage Compliance	-2.5V to +5.5V	-2.5V to +5.5V
Max Initial Offset Error	+/- 40mV	< +/- 15mV
Typical Initial Offset Error	+/-16mV	+/-6mV
Single/Dual threshold	Dual	Dual
Input Impedance	100K	100K
Programming Resolution	8mV	2.3mV
Load Circuits		
Voltage Compliance	-2.5V to +5.5V	-2.5V to +5.5V
Pullup / Pulldown	Yes	Yes
Current	+/- 5mA	+/-2.7mA
Load Resistance	2.1K	3.3K
Programming Resolution	8mV	2.3mV

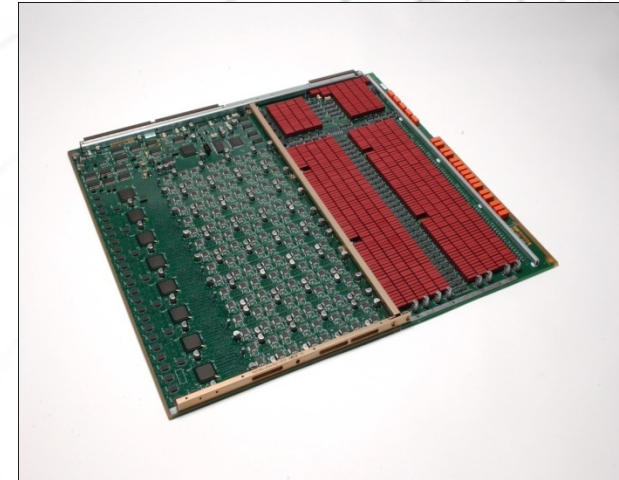
UltraPin II is designed to support testing of future device technologies

Introducing UltraPin II 121 Pin Board

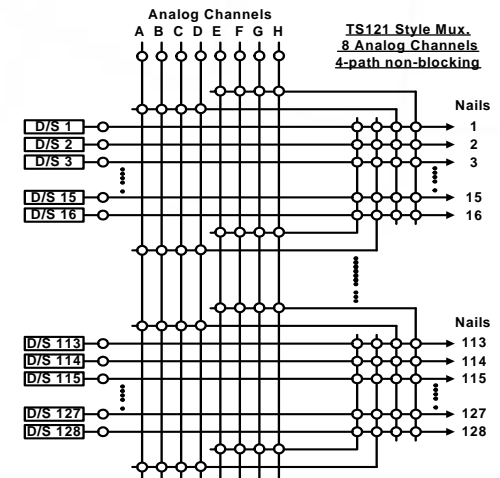


• New UltraPin II 121 Pin Board

- *Non-multiplexed* analog/digital pin board – all real pins
 - 128 shelf pins - 128 UltraPin II driver/sensors
 - 8 Analog channels with non-multiplexed 4-wire operation (conflict free 4-wire analog tests)
- Lower per pin pricing than previous UltraPin 121
- Successfully tested for compatibility and performance at customer locations
- Began shipping in May of 2006

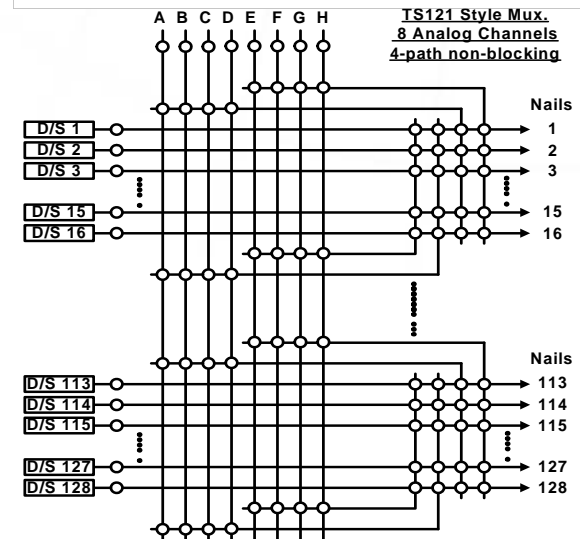
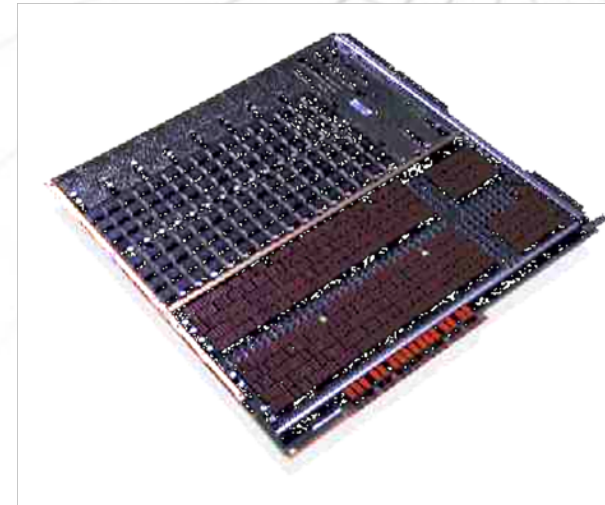


Designed to be compatible with all UltraPin I test fixtures and test programs



Introducing Analog Only 121A Pin Board

- New 121A Analog Only Board
 - *Non-multiplexed* analog only pin board
 - 128 Analog test pins
 - 8 Analog channels with non-multiplexed 4-wire operation (conflict free 4-wire analog tests)
 - Can be installed in the TestStation to create an **Analog Only** tester configuration
 - Direct replacement for older Stinger analog-only test systems
 - Can be mixed with **UltraPin II 121** digital pin boards
 - Allows manufacturers to add digital test capabilities as their products advance
 - Improved price/performance flexibility
 - Compatible with analog and vectorless testing on UltraPin I and GR228X test systems



TestStation Pin Board Family

Total flexibility to match pin count, technology, and budget requirements

Pin Board Type	Analog Test	Digital Test	Pure Pin	High Density	Pin Board Mix	Real Pin Ratio
Analog 121A	✓	✗	✓	✗	Yes, with Ultra II 121	0/128
UltraPin II 121	✓	✓	✓	✗	Yes, with Analog 121	128/128
UltraPin 128	✓	✓	✗	✗	No	16/128
UltraPin 124	✓	✓	✗	✗	Yes, with Ultra 128L	32/128
UltraPin 128L	✓	✓	✗	✓	Yes, with Ultra 124	32/256
UltraPin 124L	✓	✓	✗	✓	No	64/256

TestStation - Designed to Have the Fewest Multiplexing Restrictions

Shading indicates potential program, fixture, or debug limitations

	Pure Pin System A	Pure-Pin System B	TestStation
Drivers and Sensors	Non-multiplexed (1:1 ratio)	Non-multiplexed (1:1 ratio)	TS121- Non-multiplexed (1:1 ratio) or TS124 - multiplexed (1:4 ratio)
Analog Inst Bus	Analog ICT tests with remote sensing have restrictions	Analog ICT tests with remote sensing have restrictions	8 Channel analog bus (TS121- non-blocking 4-wire)
Logic Levels	Single-level threshold	Dual-level threshold	Dual-level threshold
Slew Rate	Not programmable, slew rate fixed at 300V/ μ S for all pins	Not programmable, slew rate fixed at 180V/ μ S for all pins	Programmable per pin 50V/ μ S – 300V/ μ S
Logic Assignment	Per pin logic programmability	Groups of 32 pins	Per pin logic programmability
Driver Architecture	Uni-directional. Low logic level is tied to GND	Bi-directional. Both low and high logic levels are programmable	Bi-directional. Both low and high logic levels are programmable
Accuracy	Capable of accurately testing low voltage technologies	Inaccurate drivers and sensors hinder testing of low voltage technologies	Capable of accurately testing ultra low voltage technologies

Teradyne TS121 provides *true* non-multiplexed operation !

New and Improved Interactive Debug Software Environment...

Design goals

1. Simplified user interface - make it easier for inexperienced operators to use
2. Utilize latest Windows technology and graphical features
3. Allow quick navigation to component tests
4. Allow user to perform most debug activities using only the mouse
5. Reduce learning curve for new operators
6. Reduce operator need to learn test language and debug commands
7. Provide quick access to circuit, fixture, and tester information
8. Provide quick feedback on test quality status and statistics
9. Expose and make it easy to access advanced features of tester
10. Provide optional command interface for expert users

Announcing *Debug Pro* - Debug User Interface

The screenshot displays the Debug Pro software interface. The main window title is "Debug Pro - C:\users\My_GRDemo\binary\LH124sys\MergedTestProgram. obc". The interface includes a menu bar (File, Edit, View, Tools, Debug, Plot, Options, Help), a toolbar with "Run" and "Stop" buttons, and a "Label Navigator" on the left. The "Label Navigator" shows a tree view of components, with "RESISTORS (SETOHM)" expanded to show components R11 through R42. The main display area shows the test results for component R17: "R17 PASS: 100 FAIL: 0". Below this, a table shows the test configuration for "2: Measure Resistance":

Parameter	Value	Unit
Avg	2.486K	
Low Limit	2.36K	Ohm
High Limit	2.63K	Ohm
Source Voltage	18	V
Setup Delay	1	ms
Result Variable		

To the right of the table is a histogram titled "2: Measure Resistance" showing the distribution of measurements. The x-axis is "Value Ranges in K (1e+3)" and the y-axis is "Measurements". Below the histogram, the following statistics are displayed:

Statistic	Value
Component Name	17
Mean	2.4928K
Low Limit	2.36K
High Limit	.63K
Std Deviation	0.0517
Cpk	0.8562
Sample Size	301
Cp	0.8704

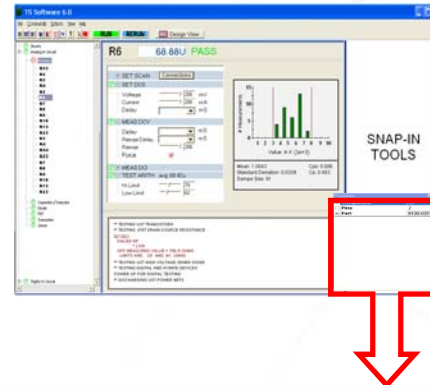
At the bottom of the interface, there is a "Command History" section showing the following commands:



```
** DISCHARGING OUT CAPACITIVE VOLTAGES  
** CHECKING CONTACT BETWEEN OUT AND TESTER  
** TESTING FOR OPEN AND SHORTED NODES  
** TESTING FOR OPENS USING TEST XPRESS  
** TESTING OUT RESISTORS
```

The "DEBUG" prompt is visible at the bottom left, and the status bar at the bottom indicates "Executing Test".

Debug Pro - Component Properties Tool

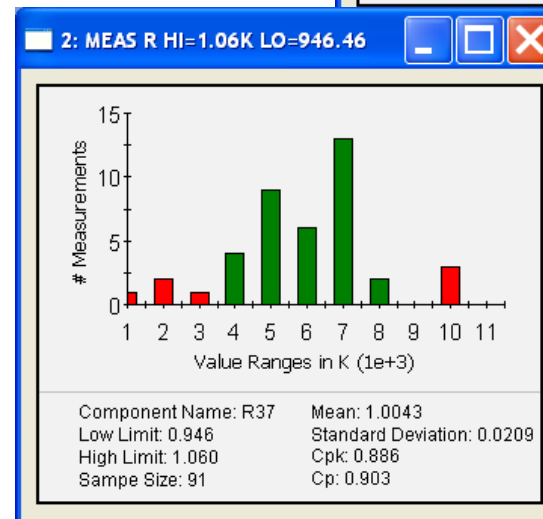
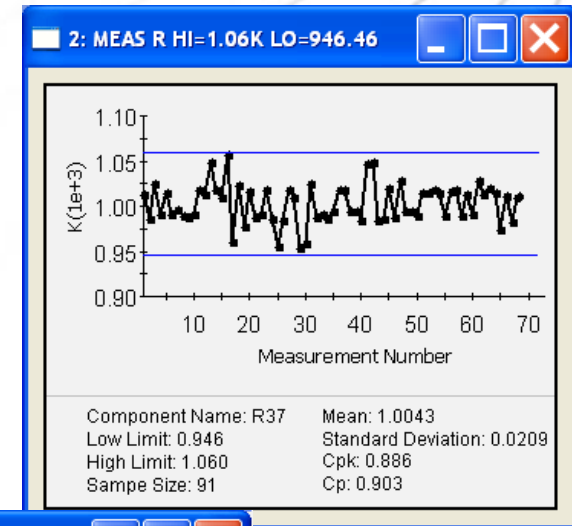
- Displays component specific information
 - Reference Designator
 - Type
 - Style
 - Value and Tolerance
- Pin connections
 - Pin Name
 - Associated Net
 - Associated Nail(s)



Properties	
<input checked="" type="checkbox"/> Component	R6
Device Type	RES
Style	R-RX,10.0K,5%,CHP
Value	10.00K
NTol	5
PTol	5
<input type="checkbox"/> Pins	
 1	(UN168HC1190PXTAL) Nail 16
 2	(GND) Nail 190

Debug Pro - Statistics and Chart Tool

- Displays multiple measurements for a given test
- Identifies marginal and intermittent tests
- Run chart or histogram view
- Statistics including:
 - Mean
 - Standard Deviation
 - Cpk
 - Cp



Debug Pro - Other Tools

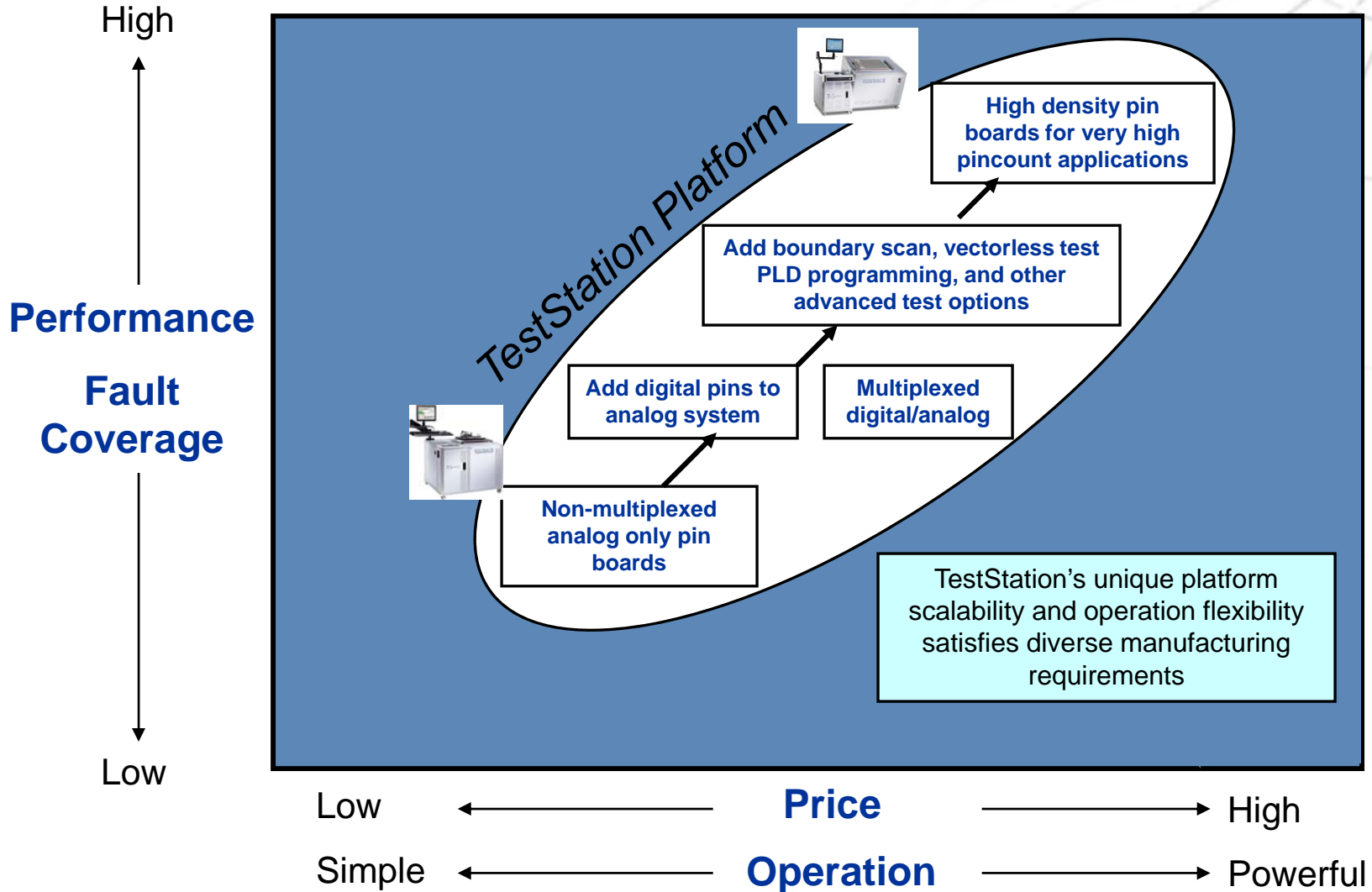
- Board and Schematic Viewers
- Data Display Data Collection reports
- Test Quality Tools
- Vectorless Test UI

The screenshot displays the Debug Pro software interface with several key windows:

- BOARD - G1000**: A physical board view showing components and test points.
- SCHEMATIC - Sheet 2**: A schematic diagram of the board's internal circuitry.
- Component**: A list of components with properties such as Part, Package, Layer, Position, and Test Techniques.
- Data Display**: A window showing test data collection reports, including a graph of High, Mean, and Low values over time.
- Runtime Test Quality**: A window showing test quality metrics and results.
 - Analog Tests**: 84.8% Passing, 15.2% Marginal, 0% Failing, 0% Intermittent.
 - Digital Tests**: 92.7% Passing, 7.3% Marginal, 0% Failing, 0% Intermittent.
 - Analyze Summary - Friday**: A summary of test results with a 'Run' button.
- Test Pin Opens**: A table listing board components and their pin counts.

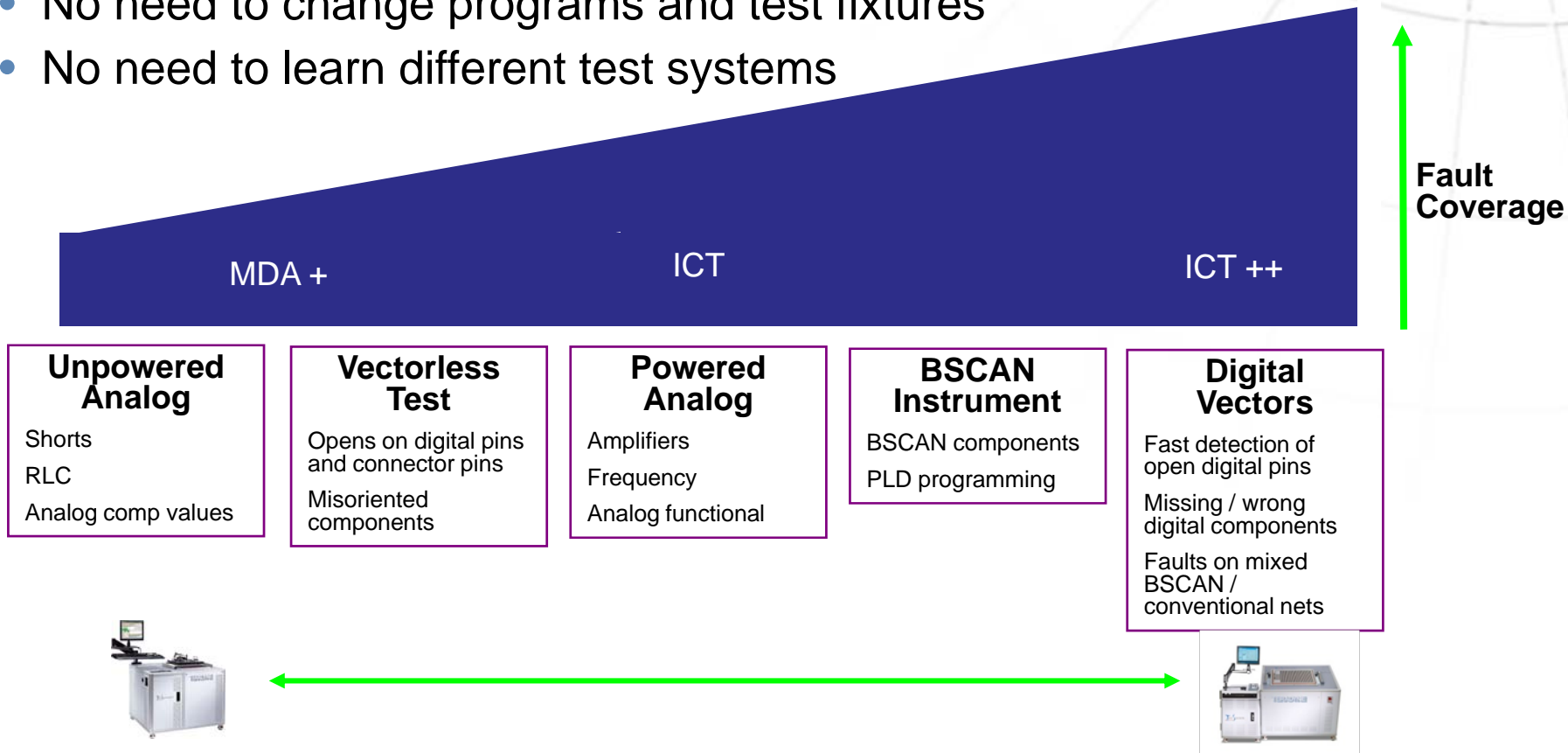
Name	Type	Part #	Pin Count
C51	CP	4450-6465-00	2
C52	CP	4450-6465-00	2
C50V	CP	C16, C47, C48 IN PARALLEL	2
CVCC	CP	+5V BYPASS (VCC GND)	2
J1	LR10	423002040	10
R42	R420PM	6730-5324-00	4
T2	XPM1	5000-8100-00	4
U1	LT1366	5462-0347-00	8
U10	74HC373	5481-8222-00	20
U11	LT1036D	5481-8251-00	8
U12	AD7524AN	5466-0025-00	20
U12_FUNC	DA08BIT	FUNCTIONAL TEST FOR AD7524	12
U13	74HC245	5481-0179-00	20
U16	MTC5268	5465-0024-00	28
U15	MTC5268	5465-0021-00	28
U16	74HC104	5481-8294-00	14
U17	LT1174	5462-0347-00	8
U2	LT1366	5462-0347-00	8
U3	74HC00	5481-8394-00	14
U4	MC58HC11E9	5461-6344-00	62

TestStation Platform Flexibility



TestStation Platform Satisfies Diverse Manufacturing Requirements

- Buy only the test capability you need
- Grow or reduce fault coverage without changing the tester
- No need to change programs and test fixtures
- No need to learn different test systems






Summary: TestStation Platform Benefits

TestStation satisfies diverse manufacturing requirements

- ✓ Supports different PCB complexities
 - Analog only to high performance digital
 - Low pin count to high pin count applications
- ✓ Supports different PCB cost models
 - Low cost **MDA+** configurations
 - Affordable **ICT** configurations
 - High performance **ICT+** configurations
 - Reduced training and maintenance costs
- ✓ Supports manufacturing flexibility
 - Easily moved to different sites and configured to match test requirements
 - Maximum test equipment utilization
 - Reduced program maintenance (common fixture and program run on all configurations)
- ✓ Supports different volumes and mix
 - Rack mount components for fast integration into automated handlers
 - Fast re-configuration of the system on the fly
- ✓ Supports different operator skill levels
 - New and experienced users
 - Skilled and un-skilled operators
- ✓ Supports regulatory obligations
 - UltraPin II and SafeTest protection technologies
 - Advanced VLSI test vectors and timing
- ✓ Supports user development preferences
 - Multiplexed or non-multiplexed operation
 - Graphical or command line debug environment

TestStation Model Comparison

Feature	TestStation LH 	TestStation 	TestStation LX 
Max Pin Capacity	2,048 / 4,096	3,840	7,680
Maximum Pin Boards	16	30	30
Supported Pin Board Types	Ultra II 121, 121a Ultra 124, 128, 124L, 128L	Ultra II 121, 121a Ultra 124, 128	Ultra 124 Ultra124L, 128L
Real Pin Count Range	256 to 2,048	480 to 3,840	960 to 1,920
Supported Fixture Types	Small, half-size, LH	Small, half-size, and standard	Small, half-size, LH, standard, and large
Clock/Sync/Trigger Pins	Optional	Standard	Standard
Backdrive Control	Optional	Standard	Standard
FrameScan Technology	Optional	Optional	Optional
SafeTest Technology	Yes	Yes	Yes
GR 8X Compatible	Yes, small or half-size fixture types	Yes, all fixtures except large	Yes



Q&A

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Assembly Test Division